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January 20, 2020

Jonathan Smies, Attorney
Godfrey & Kahn, SC
200 South Washington Street
Suite 100
Green Bay, Wisconsin 54301-4298

Subject: Opinion on the Need to Remove Solids

Dear Mr. Smies:

Summary and Conclusions

The Green Bay Metropolitan Sewerage District (also known as NEW Water) experienced difficulties with their biosolids incineration system beginning in the late summer and continuing into the winter of 2019 that negatively impacted their ability to manage the solids produced by their wastewater treatment facilities. These difficulties included failure of a thermal oil waste heat exchanger in late July and August and a thermal excursion in the granular activated carbon (GAC) air pollution control system that occurred November 7 during restart of the incineration system following a normally scheduled preventative maintenance event. NEW Water elected to begin operation of the incineration system on November 21, 2019, even though the GAC air pollution control system was not operational. You requested my opinion on the need to remove solids from the Green Bay Facility during the time that the GAC air pollutions control system was unavailable.

You requested that I describe what the consequences of failing to remove solids during this period would have been. You have chosen me for this engagement based upon my qualifications. A summary of my biography is attached as Appendix B.

My response to your question is based on my prior knowledge of the NEW Water facilities, a phone conversation with NEW Water staff and you and colleagues November 20, 2019, review of an information package provided by NEW Water, and analysis of plant operating data. I found that the prior outages of the incineration system, largely to complete normal preventative maintenance, lead NEW Water to largely exhaust their in-plant solids storage capacity. Even though they practiced landfilling of sludge consistently whenever the incinerator was out of service, it was insufficient to process the normal liquid process sludge production. Consequently, if additional sludge processing through the incinerator had not occurred while the GAC air pollution control system was out of service, a significant discharge of $cBOD_5$, TSS, and TP would have occurred within a week or two, with effluent concentrations significantly exceeding plant effluent discharge standards.

Background and Charge

The Green Bay Metropolitan Sewerage District (also known as NEW Water) owns and operates two Wastewater Treatment Facilities, the Green Bay Facility (GBF) and the De Pere Facility (DPF). The GBF (Figure 1) treats 32 million gallons per day (MGD) of municipal and industrial wastewater on average, and the DPF (Figure 2) treats 8 MGD of municipal and industrial wastewater on average. GBF influent

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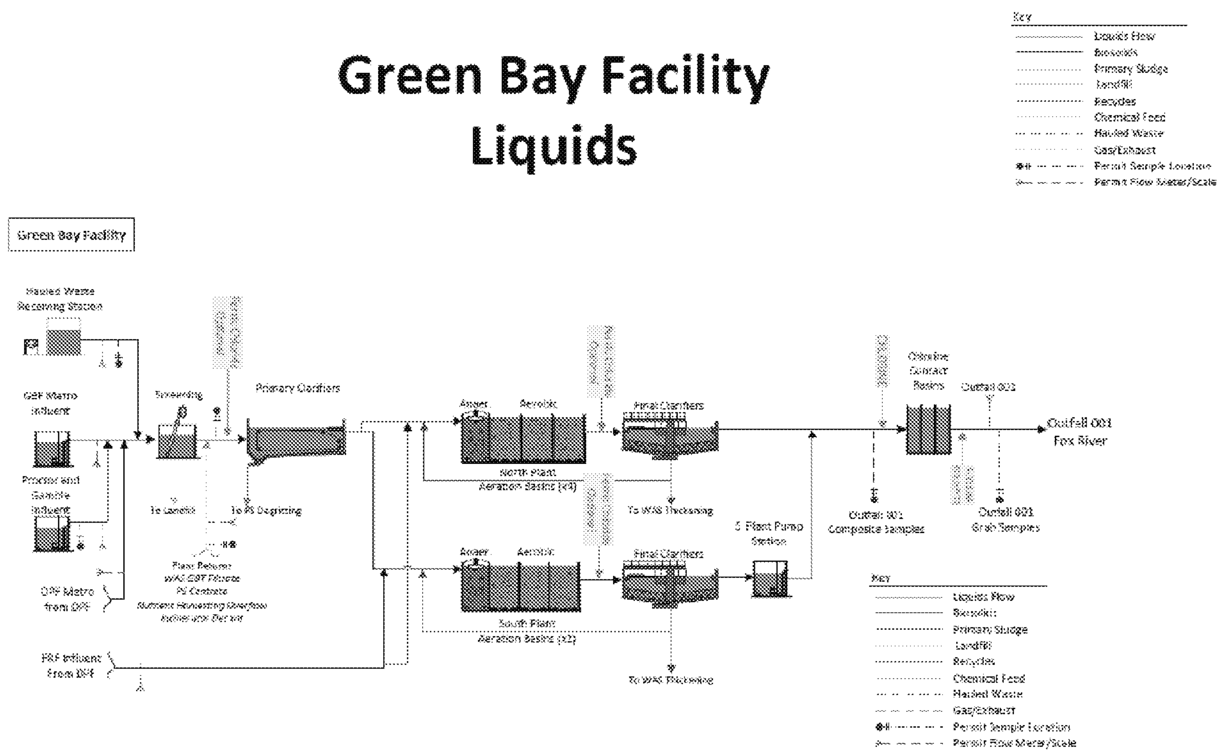

Figure 1. GBF Liquid Process Train.

wastewater is first screened to remove large particulate matter and then primary treatment to remove settleable organic matter. Biological treatment to remove further biodegradable organic matter, phosphorus, and to convert ammonia-nitrogen to nitrate-nitrogen (nitrification) is provided in parallel activated sludge systems. Chlorine disinfection is provided prior to discharge to the Fox River.

Municipal wastewater influent to the DPF receives preliminary treatment consisting of screening to remove large particulate matter followed by grit and fats, oil, and grease (FOG) removal. Pre-treated municipal wastewater is combined with a portion of Fox River Fiber wastewater and subjected to two-stage biological treatment for the removal of biodegradable organic matter, phosphorus and nitrification. Activated sludge effluent is subjected to filtration for further suspended solids removal using multi-media filters prior to ultra-violet disinfection prior to discharge to the Fox River.

Solids produced as a result of wastewater treatment at the DPF are pumped to the GBF for processing. Grit is removed from the GBF primary sludge prior to gravity thickening. DPF and GBF waste activated sludge (WAS) from their activated sludge systems is subjected to pre-thickening, phosphorus release, and post-thickening to extract phosphorus for recovery. Thickened primary sludge and WAS, along with high strength waste, is subject to anaerobic digestion to convert biodegradable organic matter into biogas. Anaerobically digested sludge is dewatered, partially dried, and combusted in a fluidized bed incinerator. Incinerator ash is landfilled, and provisions are provided to also allow dewatered anaerobically digested sludge to be landfilled as a back-up to the incinerator. Biogas produced in the

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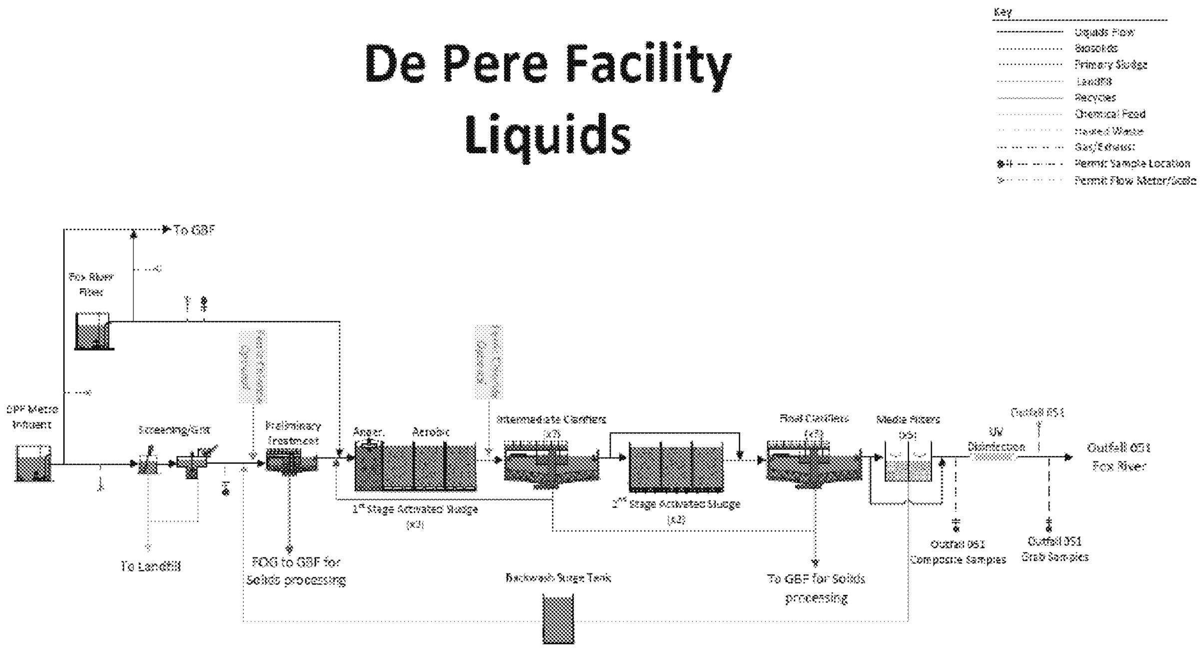

Figure 2. DPF Liquid Process Train.

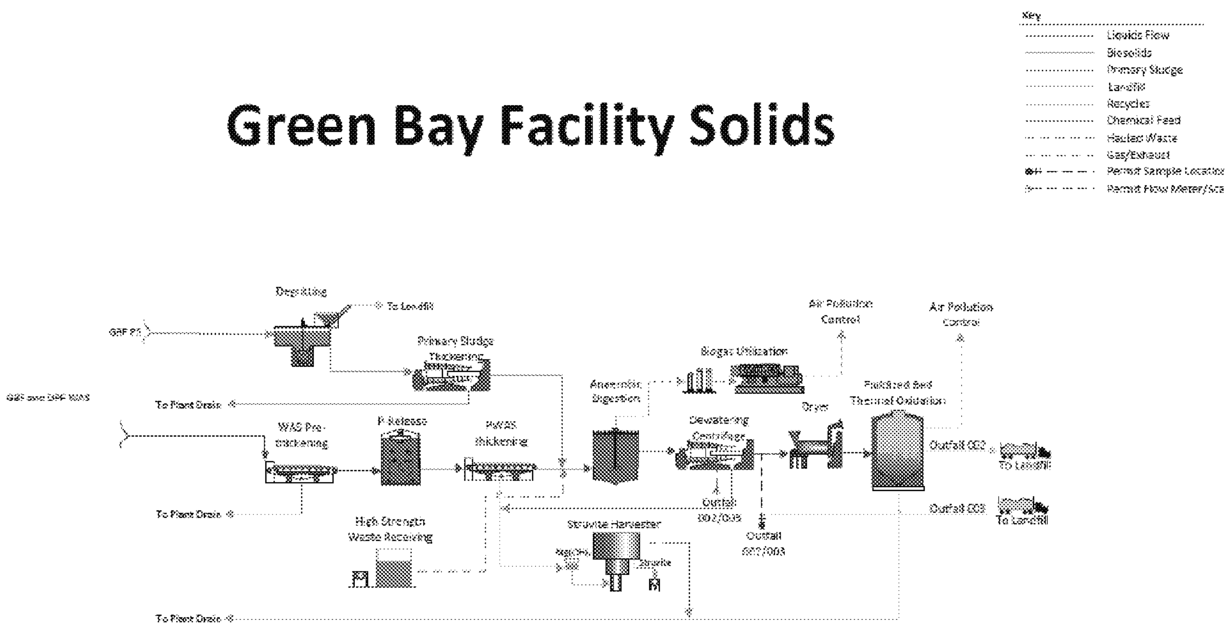

Figure 3. GBF Solids Process Train

anaerobic digester is pre-treated to remove moisture, hydrogen sulfide, and silicone-containing compounds (siloxanes) prior to utilization for electricity and heat production. Further details are provided in Appendix A: Facility Descriptions.

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Effluent limits for the GBF consist of standard secondary treatment requirements, seasonal effluent ammonia limits that vary from 4.7 to 26 mg-N/L on a monthly average basis, and a monthly average effluent total phosphorus (TP) limit of 1 mg-P/L. Monthly average effluent five-day carbonaceous biochemical oxygen demand ($cBOD_5$) and total suspended solids (TSS) limits for the DPF are more stringent at 9 and 10 mg/L, respectively, and the seasonal monthly average effluent ammonia limits are somewhat less stringent and range from 24 to 31 mg-N/L. The DPF monthly average effluent TP limit is the same as for the GBF at 1 mg-P/L. Weekly average $cBOD_5$ mass limits also exist for the period of May through October for NEW Water that can represent more stringent effluent $cBOD_5$ limits than listed above.

NEW Water experienced difficulties with their biosolids incineration system beginning in the late summer and continuing into the winter of 2019 that negatively impacted their ability to manage the solids produced by their wastewater treatment facilities. These difficulties included a thermal excursion in the granular activated carbon (GAC) air pollution control system that occurred during restart of the incineration system following a normally scheduled preventative maintenance event. Operation of the GAC system is required to comply with mercury emission requirements associated with operation of incineration. In spite of this, NEW Water elected to begin operation of the incineration system on November 21, 2019 to avoid adverse consequences to the system resulting from the accumulation of solids within the treatment system. You requested my opinion on the need to remove solids from the Green Bay Facility during the time that the GAC air pollutions control system was unavailable. You requested that I describe what the consequences of failing to remove solids during this period would have been. You have chosen me for this engagement based upon my qualifications. A summary of my biography is attached as Appendix B. The purpose of this letter report is to respond to your request.

Information Reviewed

My opinion is based on my prior knowledge of the NEW Water facilities, a phone conversation with NEW Water staff and you and colleagues November 20, 2019, and an information package provided by you consisting of:

- A qualitative description of plant operating conditions for July 28, 2019 through approximately December 20, 2019 (DPF/GBF)
- Microbiology reports (GBF)
- MCRT and loading spreadsheets (DPF/GBF).
- SVI and settling data (DPF/GBF).
- Solids processing (landfill and Incineration) dry tons/day. (GBF)
- Plant influent and effluent data (GBF/DPF).
- MLSS/RAS concentrations (GBF/DPF).
- Digester Process Conditions Information (GBF)

The quantitative data were generally provided for January, 2019 through about mid-December, 2019.

Table 1 is abstracted from the Word document titled "Plant Conditions – Qualitative Description" and summarizes the key events during the second half of 2019. Wastewater solids are normally processed

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through thickening, anaerobic digestion, dewatering, partial drying, and incineration. Solids processed through thickening, anaerobic digestion, and dewatering are landfilled during periods when incineration is not available. Constraints associated with landfilling result, however, in an inability to transport all of the produced solids to the landfill, making it necessary to store solids in the liquid process train. Note that NP refers to a bioreactor in the GBF North Plant, SP refers to a bioreactor in the GBF South Plant, and P release refers to tankage that is part of the solids processing system. It is noted in the subject document that a means to meter sludge being stored in offline bioreactors is not available, which negatively impacted management of the mean cell residence time (MCRT) of the plant activated sludge process. The MCRT is the average time that produced solids are retained in the activated sludge system. It is one of the most important activated sludge process control parameters because it directly controls the rate at which the microorganisms that are responsible for wastewater treatment are growing, and consequently the rate at which they remove pollutants. Limited ability to control the rate at which solids are removed from the process means that the length of time they remain in the system is poorly controlled, negatively impacting the ability to control pollutant removal. MCRT control is also necessary as the mass of solids that can be maintained in the activated sludge process (often referred to as the solids inventory) has a finite limit based on the facility design. Reduced control of the activated sludge inventory can result in the retained inventory to exceed the solids holding capacity of the system, resulting in discharge of the excess solids into the effluent and significant deterioration in effluent quality. Plant operators indicate that NP-4 and the P-release tank are still full of solids and will likely remain there until spring. They intend to eventually send these solids directly to the thickening process, and subsequently through the solids processing train, to limit negative effects on the liquids train. It is noted that transfer of NEW Water influent from DPF to GBF was initiated November 21, 2019 to provide additional loading to GBF and stabilize DPF. DPF has been relatively stable throughout the outages. While noted, this change would have had limited impact on solids processing at the GBF.

In this same document, plant operations staff note that increased filament activity, surface foaming, and effluent TSS were noted during periods that solids were stored in the liquid process. Biological phosphorus removal has been stable during this period, with better ortho-phosphorus release in the selector zones despite the high aluminum and iron loads to the head of the plant. I was aware that the plant has been experiencing higher than anticipated influent aluminum and iron loads for several months. These higher loads benefit phosphorus removal but adversely impact biological phosphorus removal and the ability to recover phosphorus in the solids processing train. This observation is not particularly material to this analysis. Returning to observations by plant operations staff, effluent quality was consistent and within permit parameters, but they were concerned about maintaining effluent quality if an event such as high flows or a toxic load occurred. Foaming was also observed to have a negative impact on final clarifier performance due to the accumulation of solids which can adversely impact effluent quality and interfere with normal operating of treatment units. The potential for freezing of accumulated foam, for instance on secondary clarifier skimming equipment in cold

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weather situations, is a particular concern because it can require high levels of operator engagement. Normal operation of the anaerobic digestion process was negatively impacted by reduced WAS loading

<table>
<tr><th colspan="4">Table 1. Summary of Events. Abstracted from "Plant Conditions – Qualitative Description".</th></tr>
<tr><th>Dates</th><th>Incinerator Operation</th><th>Dates</th><th>Solids Management</th></tr>
<tr><td>Jul. 28 – Aug. 5</td><td>Incinerator offline due to a thermal oil waste heat exchanger failure.</td><td rowspan="3">Aug. 1 – Aug. 20</td><td rowspan="3">Filled NP-2, NP-4 and SP-1 with RAS. About 4.01 MG of storage is provided in each of NP-2 and NP-4. SP-1 holds about 2.75mg for a total storage of 10.77mg or 12.06 days of storage assuming a RAS wasting rate of 620gpm from both DPF and GBF. That said, the storage was used over a longer duration as wasting was still being processed on the GBT's at reduced rates.</td></tr>
<tr><td>Aug. 6 – Aug. 8</td><td>Incinerator online.</td></tr>
<tr><td>Aug. 9 – Aug. 20</td><td>Incinerator offline due to the thermal oil waste heat exchanger failing again.</td></tr>
<tr><td>Aug. 21 – Oct. 19</td><td>Incinerator online after repair.</td><td>Aug. 21 – Oct. 19</td><td>All solids stored in NP-2, NP-4 and SP-1 were slowly pumped back into the system and the bioreactors were put back to a standby condition. Overall basin foaming and foam carryover to the finals was noted throughout the basin pump out. Filament growth was noted, and characteristics of older sludge age were witnessed throughout. Drastic swings in MCRT were experienced during this time period as well.</td></tr>
<tr><td>Oct. 19 – Nov. 6</td><td>Incinerator offline for yearly PM.</td><td rowspan="2">Oct. 19 – Nov. 10</td><td rowspan="2">Solids again stored in NP-4 and SP-1.</td></tr>
<tr><td rowspan="4">Nov. 7 – Nov. 20</td><td rowspan="4">Incinerator remains offline due to thermal excursion of GAC during restart of incinerator.</td></tr>
<tr><td>Nov 13</td><td>NP-2 was placed online to handle extra flow and store solids.</td></tr>
<tr><td>Nov 14</td><td>Settled RAS in NP-4 and pumped clean water off the surface. Did this two times to allow for more storage in NP-4. Solids concentration being stored in NP-4 at about 3%. Basin unavailable to go online if needed. P release was filled with RAS, giving 0.39mg of storage or about 10 hours.</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Nov. 21 - Present</td><td>Running incinerator without GAC intermittently, as needed to protect proper functioning of treatment facilities, with landfilling as primary disposal method.</td><td></td><td></td></tr>
</table>

during periods when solids were storage and not processed through the anaerobic digesters. For example, a substantial drop in digester alkalinity and overall biogas production in the anaerobic digesters was observed during periods when WAS transfer to the solids process train from the activated sludge process was reduced. This recovered after more normal operation of the activated sludge was initiated when incineration was initiated November 21, 2019.

I analyzed the sludge processing data for 2019 provided by NEW Water. This allowed me to calculate the typical mass of digested and dewatered sludge processed through the incineration system under typical operation. I was further able to compare the normal sludge processed to the mass that could be landfilled. The period of January through July represents typical operating conditions and, during this period, the daily average sludge processed through the incineration system averaged 28 dry tons of solids/day and ranged from 24.2 dry tons/day in March to 31.5 dry ton/day in May. In contrast, only 16.6 dry tons of solids were landfilled per day when the incinerator is out of service, ranging from 12.2 dry tons/day in July and 19.2 dry tons/day in December. Thus, when the incinerator is out of service, sludge disposal was reduced by one-third or more compared the mass that would normally be processed through the incineration system.

Consequences of Failure to Remove Solids

The consequences of failing to remove produced solids from the liquid process train of an operating wastewater treatment facility are well known. Solids are removed from the influent wastewater in the primary treatment process, while solids are produced through the further removal of suspended solids and the growth of microorganisms in the activated sludge process. Solids must be removed from the liquid treatment process at the rate they are produced through removal in the primary treatment process and removal and growth in the activated sludge process. If they are not removed from the liquid process train at the rate they are produced, solids will accumulate in the liquid treatment process at a rate equal to the difference between the rate of solids production and removal. In the extreme, when the solids storage capacity of the liquid treatment process is exceeded, excess solids (the difference between solids production and removal) are discharged into the effluent. In such cases the effluent $cBOD_5$, TSS, and TP concentrations can be significantly greater than plant discharge limits, with $cBOD_5$ and TSS effluent concentrations exceeding discharge limits by several 10's of mg/L (compared to monthly average discharge limits for the GBF of 25 and 30 mg/L, respectively), and by several mg/L for TP (compared to the monthly average discharge limit for DPF and GBF of 1 mg-P/L). Depending on the difference between sludge production and sludge removal, effluent concentrations can be several times greater than effluent discharge limits.

Solids storage in the GBF primary clarifiers is limited. This occurs because grit removal is not included in the design of the plant headworks and is allowed to pass onto the primary clarifiers where it is removed with the primary sludge. Proper functioning of the downstream primary sludge degritting units necessitates maintaining a relatively low primary sludge solids concentration, which is accomplished by pumping at a sufficient rate which limits the ability for primary sludge to accumulate in the primary clarifiers. Degritted primary sludge is subsequently thickened in gravity thickeners prior to anaerobic digestion. Using primary clarifiers for sludge storage results in a number of conditions that adversely

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impact plant performance, including the development of anaerobic conditions that produce readily biodegradable organic matter and hydrogen sulfide which adversely affect the performance of the downstream activated sludge process. Moreover, preferential transfer of primary sludge to the solids process train is desired when solids processing is limited because greater destruction of sludge solids occurs for primary sludge in anaerobic digesters than for activated sludge solids, thereby partially mitigating negative impacts on the capacity of the solids processing train. Note that, even if solids were accumulated in the primary clarifiers, the storage capacity would only correspond to a few days (around 3 to 5) of primary sludge production. Also note that primary clarifiers are not provided at the DPF.

Solids can also be accumulated in the activated sludge system. It is possible at any time that plant flows and loads are less than design values so that not all treatment infrastructure is needed to meet effluent discharge requirements. At such times, unneeded treatment infrastructure can be taken out of service to reduce operating costs while still complying with effluent discharge requirements. The out-of-service infrastructure is then available for other purposes, such as the storage of solids when solids process train constraints result in the inability to removal all produced solids from the system. This is a fairly standard operating procedure and, as indicated in Table 1, this strategy was used by NEW Water staff during late July and August when the thermal oil waste heat exchanger failed and again in late October and early November when normal preventative maintenance was conducted. The need for sludge storage was minimized but not eliminated as landfilling of thickened, anaerobically digested, and dewatered sludge was practiced during periods when the incineration system was off-line. Note that available liquid stream solids storage capacity was already at least partially filled when failure of the GAC air pollution control system occurred in early November when the incineration system was re-started. NEW Water staff used the remaining liquid process sludge storage capacity but, as the Thanksgiving week approached, they were faced with limited options and the likelihood that landfilling would be even further reduced due to capacity limitations at the landfill.

As noted above, MCRT is an important activated sludge process control parameter. It represents the average length of time that produced solids remain in the activated sludge process as discussed above, but also quantifies the time that solids will accumulate in the system if the removal of solids is stopped. In such case, the solids inventory in the liquid treatment process would roughly double over a time period equal to the process MCRT. The GBF activated sludge was generally operated at an MCRT of 10 to 15 days. Review of the suspended solids concentration in the GBF activated sludge process indicates that it was already relatively high. Thus, it is reasonable to think that a failure to begin normal solids removal from the GBF activated sludge process at normal rates would lead to the significant discharge of accumulated solids within about a week or more. Significant wet weather flows, with further stress the activated sludge system, could cause the discharge of excess activated sludge to occur even more quickly. Effluent $cBOD_5$, TSS, and TP concentrations would be expected to significantly exceed plant discharge limits, and perhaps be two or more times greater than discharge limits. Ammonia removal (nitrification) would not be impacted as the accumulation of biological solids in the activated sludge system will actually benefit nitrification.

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This analysis of storage within the activated sludge system has focused on the GBF. Some storage capacity would be present at the DPF but is small compared to that at the GBF due to the much smaller size of the DPF and the fact that plant flows and loads are closer to facility design values.

Operation of an activated sludge system under extended MCRT conditions can lead to other adverse effects. These adverse effects can include a deterioration in sludge settling characteristics resulting in decreased ability to retain the required activated sludge biomass in the system (sludge bulking as quantified by the sludge volume index, SVI), the development of a population of small suspended solids that due not settle in the system (as quantified by effluent turbidity), and foaming. Such issues can persist over a time period equal to several times the MCRT following the initiation of normal solids processing. For the GBF this could correspond to three to four months. As noted above, foaming can be especially problematic in the winter as accumulated solids can freeze and interrupt the normal functioning of treatment units, especially secondary clarifiers.

In conclusion, the direct answer to your question concerning the consequences of failing to remove solids beyond the amount that could be landfilled during the period that the GAC air pollution control system was out of service are that a significant deterioration in GBF effluent quality would occur within one or two weeks, leading to effluent $cBOD_5$, TSS, and TP significantly in excess of plant effluent discharge standards.

Sincerely

Glen T. Daigger

Glen. T. Daigger, Ph.D., P.E., BCEE, NAE
President and Founder

Appendix A: Facility Descriptions

Overview

New Water owns and operates two regional wastewater treatment facilities: (1) the Green Bay Facility (GBF) and (2) the De Pere Facility (DPF), which was acquired in 2007. These plants serve 15 municipal customers with a combined population of approximately 232,000, spread over 285 square miles. The facilities provide liquid treatment for current average flows of approximately 32 MGD (GBF) and 8 MGD (DPF). Solids produced at each facility are treated in a common solids processing facility that is located at the GBF.

GBF Liquids

The liquids treatment process at the GBF is rated for a design flow of 49.2 MGD and is comprised of preliminary, primary and secondary treatment, and disinfection. The GBF consists of the North Plant (constructed in the mid-1970s) and the South Plant (constructed in the early 1990s). The South plant was constructed to enable GBMSD to convert from the contact stabilization process to the singe-stage nitrification/denitrification process.

Preliminary and primary treatment consists of two influent mechanical trash racks, separate pumping of municipal and paper mill wastewater using six centrifugal pumps with variable frequency drives and one constant speed pump, four step screens at 0.25-inch openings, four square primary clarifiers with corner sweeps, and degritting of primary sludge using four grit separators and two snails. Grit and screenings are hauled to landfill. Degritted primary sludge is pumped to two gravity thickeners and one centrifuge for thickening.

The secondary treatment process consists of a conventional activated sludge process designed for enhanced biological phosphorus removal, nitrification to meet seasonal ammonia limits, and BOD removal. The North Plant consists of four aeration basins, eight square final clarifiers with corner sweeps, and two chlorine contact basins. The South Plant has two aeration basins and two circular final clarifiers. South Plant secondary effluent is pumped to the North Plant secondary effluent channel prior to chlorination. Aeration basins in both plants have mechanically mixed anoxic/anaerobic zones designed for filament control and enhanced biological phosphorus removal. Air is delivered through fine bubble membrane diffusers from centrifugal blowers. Return activated sludge (RAS) from the final clarifiers is returned to the unaerated zones to promote biological phosphorus removal. Waste activated sludge (WAS) from the North and South Plants is pumped to gravity belt thickeners or a centrifuge.

The secondary effluent is chlorinated from May through September with sodium hypochlorite and dechlorinated with sodium bisulfite. Final effluent is discharged into the Fox River near its mouth to the bay of Green Bay.

DPF Liquids

The liquids facility is rated for an annual design average of 10 MGD and consists of preliminary treatment, secondary treatment, tertiary filtration, and disinfection. Since the 2007 consolidation with

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New Water, modifications have been made to direct municipal and industrial wastewater to the GBF. Flows redirected from DPF to GBF include approximately 75 percent of the Fox River Fiber Company flow and 2.0 MGD of municipal wastewater (with a maximum redirection of 3.0 MGD).

Preliminary treatment consists of a pump station with six municipal waste pumps, two fine screens, hydro cyclone grit removal, and two preliminary treatment units. DPF does not remove primary sludge from its preliminary treatment units but instead sends that material for further treatment in the first-stage aeration systems. The units do, however, remove grit and grease. Grit is transferred to landfill while the grease is trucked to the GBF for processing.

The secondary treatment process consists of two first-stage aeration basins with anoxic zones, two intermediate clarifiers, two second-stage aeration basins (no anoxic zones), and three final clarifiers. The first-stage aeration basins are operated to achieve enhanced biological phosphorus removal, nitrification, and BOD removal. The second-stage aeration basins are not utilized under normal operations but can be used if loadings increase beyond what can be handled by the first stage. Dissolved oxygen probes in the aeration system are used by the six HST blowers to maintain proper air flow and distribution. The two intermediate clarifiers separate RAS from the mixed liquor flow and the RAS is then sent back to the anoxic zone at the head end of the aeration basins. The three final clarifiers are utilized whether or not the second-stage activated sludge process being utilized to further polish the secondary effluent before entering the filtration building. WAS from the DPF is pumped to GBF for processing.

Tertiary filtration consists of five granular media filters. The five tertiary filters remove most of the remaining solids and the final effluent proceeds on to the UV system for disinfection. The DPF effluent enters the Fox River east of the facility.

GBF Solids

Primary sludge produced at GBF and WAS from both GBF and DPF is treated through a combined solids processing facility at GBF. The solids processes underwent improvements that were completed in 2018. The improvements project is referred to as the Resource Recovery and Electrical Energy (R2E2) project. R2E2 consisted of modifications to primary sludge thickening, and the addition of anaerobic digestion, dewatering centrifuges, fluidized bed incineration, nutrient recovery, and energy recovery through co-digestion and biogas energy generation.

Primary sludge is to be primarily thickened using gravity belt thickeners, with two existing gravity thickeners utilized as redundancy. WAS from both facilities is thickened using a thickening centrifuge. Thickened WAS (TWAS) is mixed with WAS to a concentration of about 2 percent in a phosphorus release tank. In the phosphorus release tank, biologically stored phosphorus in WAS is released and improves the efficiency of the nutrient recovery system. WAS from the phosphorus release tank (PWAS) is sent to a second gravity belt thickener. The third gravity belt thickener serves as a standby unit. Thickened degritted primary sludge (TPSD) and thickened PWAS (TPWAS) are combined and sent to anaerobic digestion, which consists of two silo-shaped anaerobic digesters. Anaerobically digested sludge is dewatered to about 21 percent cake using three dewatering centrifuges, dried to about 38 percent dry solids in a multiple-disc dryer, and incinerated utilizing a fluidized bed incinerator. The incinerator exhaust is treated with a multiple-stage air pollution control train. Ash removed in the scrubber is dewatered in ash dewatering cells and hauled to a landfill. The GBF also has the ability to haul anaerobically digested dewatered sludge cake to a landfill. Hauling of sludge cake only occurs when the incinerator is out of service.

The solids process includes provisions to recover energy and nutrients from the waste streams. Biogas produced in the anaerobic digestion process is collected and treated using iron sponges and activated carbon for hydrogen sulfide (H_2S) and siloxanes, prior to being utilized in biogas engines for energy production. The facility includes provisions to receive high-strength waste directly to digestion to increase biogas production. Filtrate from PWAS thickening and centrate from digested sludge dewatering are high in phosphorus and ammonia. Phosphorus is recovered from these combined side streams through the intentional formation of struvite. The controlled formation of struvite reduces nutrient recycle loading on the secondary treatment process and limits detrimental struvite production on digestion and dewatering equipment.

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Appendix B: Glen T. Daigger, Ph.D., P.E., BCEE, NAE CV

Education

BSCE, Purdue University, 1973

MSCE, Purdue University, 1975

Ph.D., Purdue University, 1979

Professional Registrations

Registered Professional Engineer, Indiana, # PE60870309; Arizona, # 47312

Board Certified Environmental Engineer, American Academy of Environmental Engineers and Scientists

Distinguishing Qualifications

Widely Recognized International Expert with Broad Experience in Water Management

More Than 40 Years Practical Experience, Including Senior Vice President at Major International Engineering Firm

Actively Involved with Over 300 US and International Water Resource Recovery Facilities Ranging in Size From < 1 to >400 mgd

Widely Published Author

Holder of Eleven Patents

Former President of the International Water Association, Providing Broad International Perspective

Member of the National Academy of Engineering and foreign member of the Chinese Academy of Engineering

Glen T. Daigger is President and Founder of One Water Solutions, LLC, a professional services firm serving the water sector. Strategic advice and technical analysis of water solutions which protect public health and the environment while delivering added value to the communities and industries served are provided. A strong foundation in science and engineering, coupled with broad and diverse experience, provides the basis for these services. Dr. Daigger is also Professor of Engineering Practice at the University of Michigan. He previously served as Senior Vice President and Chief Technology Officer for CH2M HILL (now Jacobs) where he was employed for 35 years, as well as Professor and Chair of Environmental Systems Engineering at Clemson University. Actively engaged in the water profession through major projects, and as author or co-author of more than 200 technical papers, five books, and several technical manuals, he contributes to significantly advance practice within the water profession. He has advised many of the major cites of the world, including New York, Los Angles, San Francisco, Detroit, Singapore, Hong Kong, Istanbul, and Beijing, along with a wide range of smaller cities and industries. Deeply involved in professional activities, he is currently a member of the Board of Directors of the Water Research Reuse Foundation (TWRF), and a Past President of the International Water Association (IWA). The recipient of numerous awards, including the Kappe, Freese, and Feng lectures and the Harrison Prescott Eddy, Morgan, and the Gascoigne Awards, and the Pohland Medal, he is a Distinguished Member of the American Society of Civil Engineers (ASCE), a Distinguished Fellow of IWA, and a Fellow of the Water Environment Federation (WEF). A member of a number of professional societies, Dr. Daigger is also a member of the U.S. National Academy of Engineers and a foreign member of the Chinese Academy of Engineering.

A former Chair of the Water Environment Federation (WEF) Technical Practice Committee and former chair of the task force preparing the industry-standard *Design of Municipal Wastewater Treatment Plants*, Manual of Practice No. 8, he is not only familiar with standard industry practice but has lead efforts to define it.